

Advanced Exo-Brake Development: Parachuting Small Payloads in a Single-Stage from Low Earth Orbit (LEO)

Completed Technology Project (2012 - 2013)



Project Introduction

What is an Exo-Brake/How Does it Work?: The Exo-Brake is a Exo-Atmospheric drag device that dramatically reduces the ballistic coefficient (above) such that de-orbit can occur within 2-3 days. It is semi-stiff so that it can not tangle (a driving design requirement). Because it is a tension device – it can (in later versions) be easily modulated and controlled to the top of the atmosphere at about 100 km (the von Karmen altitude). Solar sails have beams that would buckle prematurely – and gas inflation systems would not permit the fine level of control desired. The design is comprised as a 3 layer fabric sandwich that is both high temperature – and easily to fold into a tight volume.

Because of the safety and related complexities of launching – or deploying – small satellites from the International Space Station (ISS), it was necessary to devise inherently safe systems that would be compatible with storing and processing INSIDE the ISS. Normally considered propulsion systems would be challenging – as any leakage, even if a benign propellant were used – could affect crew safety (e.g., freon system leakage at above volume percentage thresholds). Cold-gas systems would require bulky 'scuba-tank' -sized high pressure cylinders. And – a solid propellant motor would present obvious risks of premature ignition. Once deployed outside the airlock, a propulsion system would be complex – and have to have a navigation, spin-up/down, and COM/tracking system. This is analogous to the operational complexity of the original Corona capsules used several decades ago for spy satellites. The Exo-Brake and related Small Payload Quick Return (SPQR) was intended to be both safe and operationally simple. It is a tension-based, semi-stiff parachute that is deployed from an aft cavity of the satellite and dramatically increases the drag. The ballistic coefficient, or $M/Cd \cdot A$ (M =mass; Cd =drag coefficient; A =projected area) is modified to a value of 1-3kg/m², and perhaps surprisingly – permits de-orbit and re-entry within 2-3 days. The SPQR – which will be later tested with the Exo-Brake – includes a unique self-orienting re-entry capsule (TDRV – Tube Deployed Re-entry Vehicle) that also departs from the current orthodoxy. Though intended for 'hot re-entry,' it is also a low-ballistic coefficient device so that peak heating is depressed -because it occurs at the very top of the atmosphere in very low density. The Exo-Brake and related technologies permit unique planetary cube-sat missions – to Mars – to be tested and perfected from the ISS. Addendum: The first Exo-Brake experiment – at small test-scale (8 kg/m²) was launched in late November, 2013 and successfully re-entered on January 6. The next flight test is scheduled for July, 2014.

Anticipated Benefits

This benefits both the SPQR (Small Payload Quick Return) capability demonstration mission and the SOAREX (Sub-Orbital Aerodynamic Re-entry Experiments) missions.



Cubesat with Exo Brake Parachute

Table of Contents

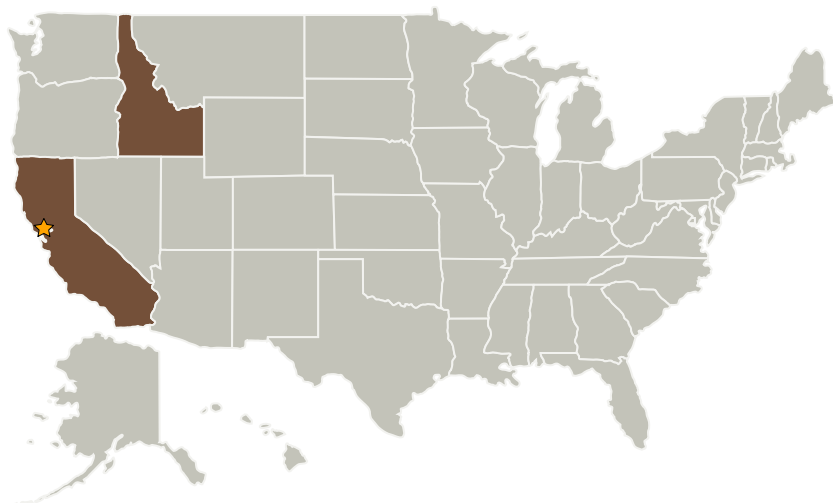
Project Introduction	1
Anticipated Benefits	1
Primary U.S. Work Locations and Key Partners	2
Organizational Responsibility	2
Project Management	2
Images	3
Stories	3
Technology Maturity (TRL)	3
Technology Areas	3

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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California

Co-Funding Partners	Type	Location
San Jose State University	Academia	San Jose, California
University of Idaho	Academia	Moscow, Idaho

Primary U.S. Work Locations	
California	Idaho

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Center Innovation Fund: ARC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Harry Partridge

Project Manager:

Marcus S Murbach

Principal Investigator:

Marcus S Murbach

Co-Investigators:

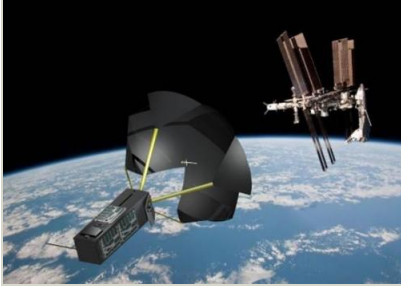
David H Atkinson
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Images



Cubesat with Exo Brake Parachute

Cubesat with Exo Brake Parachute
(<https://techport.nasa.gov/image/3078>)

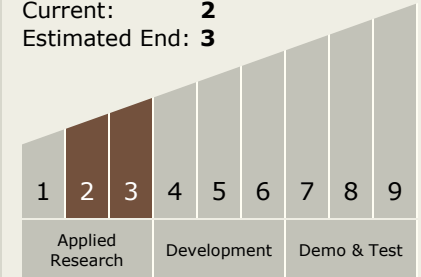
Stories

Exo-Brakes – Parachuting off of the International Space Station
(<https://techport.nasa.gov/file/35195>)

NASA Deploys Ames Satellite Designed to re-enter Atmosphere Using Revamped Drag Device
(<https://techport.nasa.gov/file/27028>)

Technology Maturity (TRL)

Start: 2
Current: 2
Estimated End: 3



Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
 - TX09.1 Aeroassist and Atmospheric Entry
 - TX09.1.3 Passive Reentry Systems for SmallSats